



May 1, 2000

Mr. William Grimley  
Emissions Measurement Center  
U.S. Environmental Protection Agency  
4930 Old Page Road, Rm. E-108  
Durham, N.C. 27709

Attn: Electric Utility Steam Generating Unit Mercury Test Program

Dear Mr. Grimley:

The enclosed Emission Test Report is for Alabama Electric Cooperative's Charles R. Lowman Plant. The test was performed on January 25 - 26, 2000 by METCO Environmental, Dallas, Texas.

I have reviewed the report and found one point that needs additional clarification. On page 2-3 of the report, paragraph 3 states that the FGD unit scrubs 80% of the flue gas, implying a 20% bypass around the scrubber. This is typical for most coal types burned by Unit 2. However, due to the logistics of the coal delivery schedule, a lower-sulfur coal was burned during the test and the bypass was approximately 65%, as indicated by the flow rates recorded in the test report. I have confirmed this with the Plant operations personnel.

If further information is needed, please contact me or Larry Spann, the AEC contact person named in the report.

Sincerely,

A handwritten signature in black ink, appearing to read 'Keith M. Stephens', is written over a faint, larger version of the same signature.

Keith M. Stephens, Ph.D.  
Manager, Environmental Services Department

KMS/ljs



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SOURCE EMISSIONS SURVEY  
OF  
ALABAMA ELECTRIC COOPERATIVE  
CHARLES R. LOWMAN PLANT  
UNIT NUMBER 2 ABSORBER INLET DUCTS  
AND UNIT NUMBER 2 STACK  
LEROY, ALABAMA  
FOR  
ELECTRIC POWER RESEARCH INSTITUTE

JANUARY 2000

FILE NUMBER 99-95CRL2

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## **1 INTRODUCTION**

### **1.1 Summary of Test Program**

METCO Environmental, Dallas, Texas, conducted a source emissions survey of Alabama Electric Cooperative, Charles R. Lowman Plant, located in Leroy, Alabama, for the Electric Power Research Institute, on January 25 and 26, 2000. The purpose of these tests was to meet the requirements of the EPA Mercury Information Request. Speciated mercury concentrations at the Unit Number 2A Absorber Inlet Duct, speciated mercury emissions at the Unit Number 2 Stack, and mercury and chlorine content of the fuel were determined. The sulfur, ash, and Btu content of the fuel were also determined.

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the Ontario Hydro Method, Revised July 7, 1999; and ASTM Methods D2234, D6414-99, E776/300.0, D-4239, D-3174, and D-3286.

### **1.2 Key personnel**

Mr. Jesse Rocha of METCO Environmental was the onsite project manager. Mr. Shane Lee, Mr. Mike Bass, Mr. Jason Conway, Mr. Scott Hart, Mr. Jason Brown, Mr. Jeff Hollingsworth, and Mr. Sean Hobbs of METCO Environmental performed the testing.

Mr. Larry Spann of Alabama Electric Cooperative acted as the utility representative. Mr. Donald Dorman performed process monitoring and sampling.

Mr. Paul Chu was the Electric Power Research Institute project manager.

**Table 1-1**  
**Test Program Organization**

Organization	Individual	Responsibility	Phone Number
<i>Project Team</i> METCO	Bill Hefley	Project Manager	(972) 931-7127
<i>Utility</i> AEC	Larry Spann	Utility Representative & Process Monitoring	(334) 222-2571
AEC QA/QC	Donald Dorman	Process Monitoring	(334) 246-5746
EPRI	Paul Chu	Project Manager	(650) 855-2812

## **2 SOURCE AND SAMPLING LOCATION DESCRIPTIONS**

### **2.1 Process Description**

C.R. Lowman Unit Number 2 is a Riley wall fired, balanced draft boiler utilizing Riley turbo burners and rated at 258 gross megawatts. This unit was placed in service in 1978.

Forced Draft (F.D.) fans force the outside air through the air heaters, into the combustion air system, and into the furnace windbox. The F.D. fans have 60% capacity each, with a maximum capacity of 330,000 cfm @ 18" static pressure, and are driven by 1,500 HP, 1,200 rpm, 4,160 V constant speed motors.

Ambient combustion air intakes through the air heaters by continuous rotating heat transfer elements for improved boiler efficiency. The elements absorb waste heat from the boiler flue gas and transfer this useful heat into the incoming combustion air. The elements that are arranged in compartments of a horizontal, radial divided cylindrical shell in the outlet ductwork of the Forced Draft fans. The air then enters the furnace windbox area of the ductwork that distributes the air necessary for the combustion of coal by the burners in the Unit Number 2 Boiler.

Pulverized coal is supplied to the burners from three ball tube mills, each rated at 72,000 pounds of coal per hour. The pulverized coal leaves these mills by pulverizer air fans that blow the coal/air mixture through pipes, through the classifiers for coarse particle screening, and finally to the eighteen respective burners in the furnace.

The combustion air and pulverized coal are burned in the furnace section of the boiler, which is a Riley Stoker Corporation, Turbo Furnace, designed for balanced draft operation, and both front and rear-firing from the burners. The burners are Riley Directional Flame Burners with adjustable secondary air adjustment and two overfire airports for Nitrogen Oxide control. The boiler steam conditions at the superheater outlet are 1,980 psig and 1,005 °F. The maximum continuous steaming rate is 1,755,000 lbs/hr. The coal/air mixture is burned in the furnace section, creating a flue gas and fly ash mixture. This flue gas/fly ash mixture continues through the convection pass of the boiler which consists of a primary superheater and reheat section for boiler efficiency.

## 2.2 Control Equipment Description

As the flue gas exits the boiler through ductwork, it enters the Research-Cottrell electrostatic precipitator, which removes the fly ash particles. This process is applied in three steps: (1) electrical charging of the suspended fly ash particles, (2) collection of the electrically charged particles in an electrical field, and (3) the removal of the precipitated ash from the collecting electrodes for proper disposal. The precipitator is a weighted-wire design, rated for 1,353,000 acfm @ 775 °F, and a collection plate area total of 440,640 ft<sup>2</sup>, and with four fields of collection. The fly ash removal efficiency of the precipitator is 99.8%.

This flue gas leaves the precipitator and enters the air heater to recover the waste heat in the flue gas and transfer it to the incoming combustion air. Upon exiting the air heater, the flue gas is transferred to the inlet side of the Induced Draft (I.D.) fans of the boiler. The I.D. fans operate at 60% capacity, with an outlet capacity of 650,000 acfm of flue gas at a static pressure of 25" of water column, based on a gas inlet temperature of 291 °F. The I.D. fans are driven by 4,000 HP, 760 rpm, 4,160 V, constant-speed electric motors.

From the I.D. fans, the flue continues through ductwork and into the Flue Gas Desulfurization (FGD) unit (the last pollution control equipment in the flue gas process). The inlet flue gas sampling ports used for testing and measuring various parameters of the flue gas are located in this ductwork just upstream of the FGD unit. The I.D. fans are located upstream at a sufficient distance to preclude a negative pressure at the sampling ports.

The FGD unit consists of a main supply ductwork to each absorber ("A" side and "B" side), and a by-pass ductwork around the FGD unit to increase stack outlet temperature and control the amount of sulfur dioxide that leaves the FGD into the unit's flue gas exit stack. The FGD unit scrubs 80% of the flue gas, and removes 85% of the sulfur dioxide in the treatment portion of the flue gas. The flue gas enters the bottom of the absorber tower and flows upward countercurrent through three stages of lime slurry spray nozzles. Hydrated lime and water is mixed to form the lime slurry. The sprays produce relatively large droplets and provide thorough contact between the flue gas and the slurry, thus removing the sulfur dioxide. The scrubbed gas exits the absorber tower and is mixed with the by-passed gas to raise the gas temperature above the water condensation temperature.

The scrubbed flue gas passes through the final section of ductwork into a 401 ft tall, 16.5 ft inside diameter, brick-lined stack. The flue gas sample on the outlet side of the FGD unit will be taken through sample ports in this stack. The final exit gas monitor station is located approximately 260 ft up from the base of the stack.

## 2.3 Flue Gas and Process Sampling Locations

### *2.3.1 Inlet Sampling Locations*

The sampling location on the Unit Number 2A Absorber Inlet Duct is 44 feet 8 inches above the ground. The sampling locations are located in a transition area of the duct.

The sampling location on the Unit Number 2B Absorber Inlet Duct is 44 feet 8 inches above the ground. The sampling locations are located in a transition area of the duct.

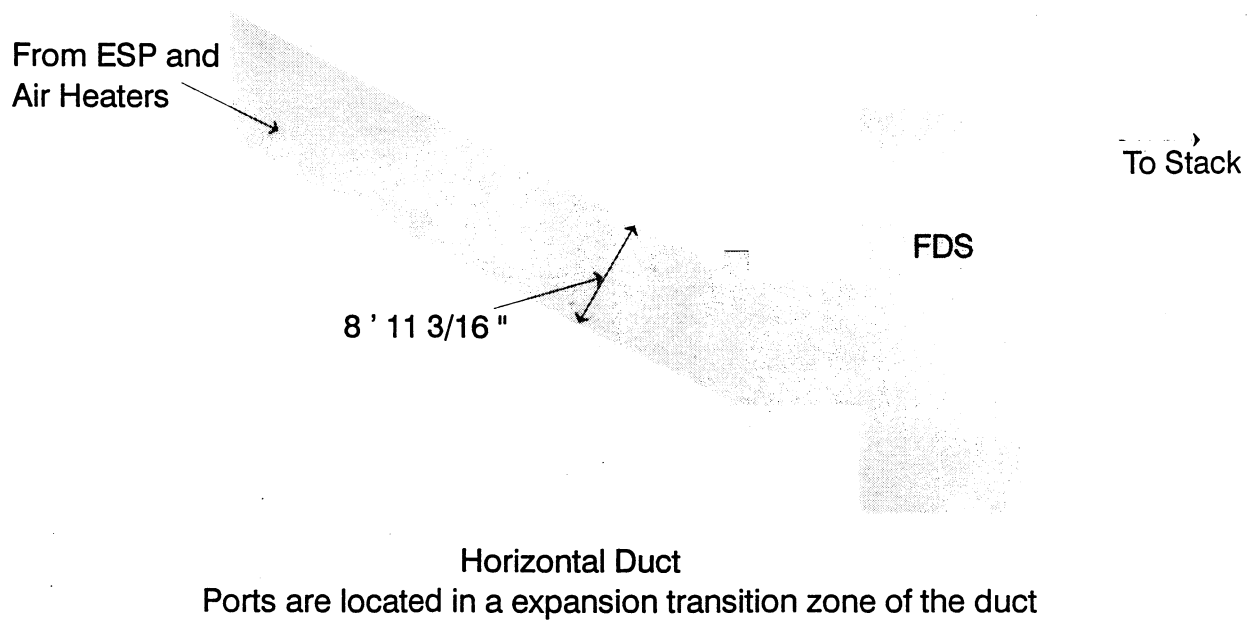
### *2.3.2 Stack Sampling Location*

The sampling location on the Unit Number 2 Stack is 261 feet 3 inches above the ground. The sampling locations are located 116 feet 3 inches (6.96 stack diameters) downstream from the inlet to the stack and 165 feet (9.88 stack diameters) upstream from the outlet of the stack.

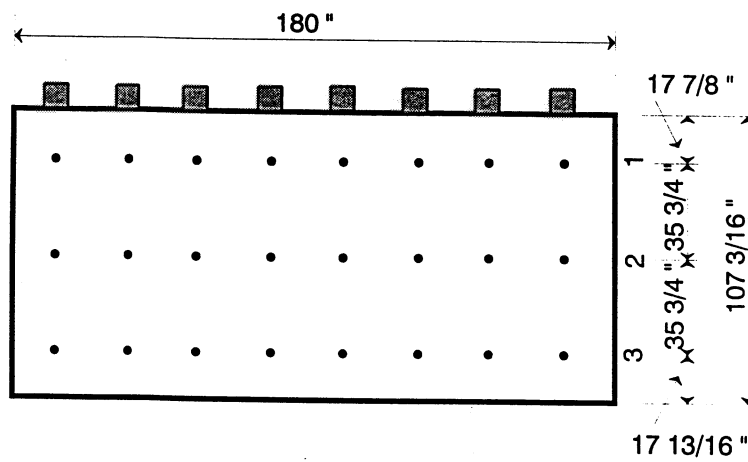
### *2.3.3 Coal Sampling Location*

The coal sampling locations are located at the coal silos.

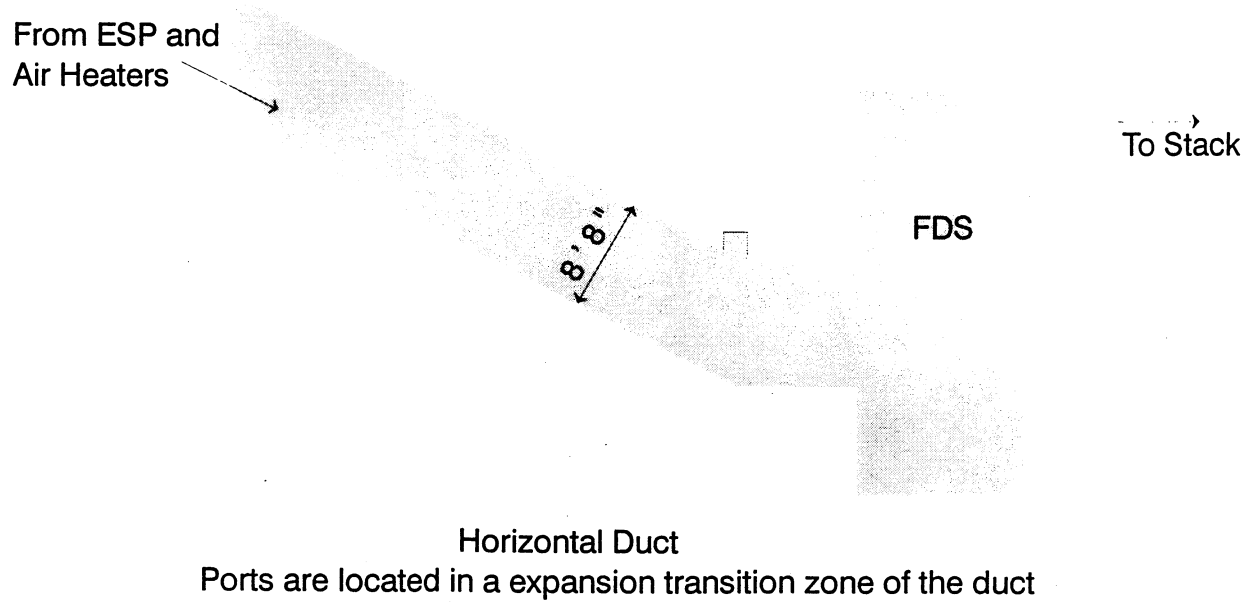
**Figure 2-1 Description of sampling locations at Charles R. Lowman Unit Number 2A Absorber Inlet Duct**



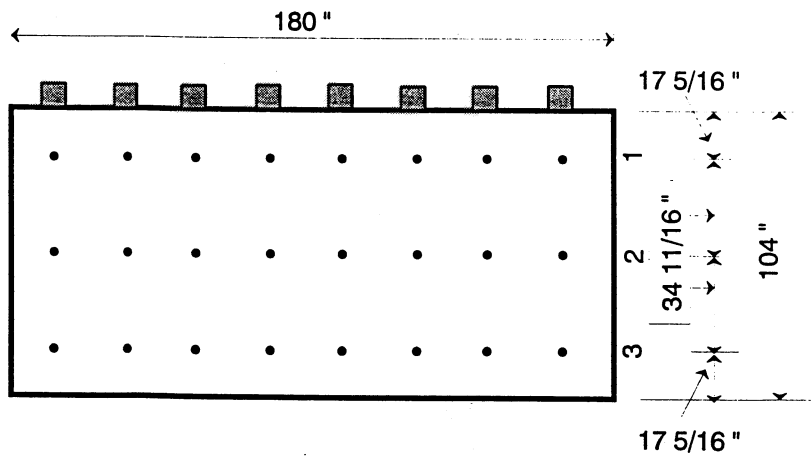
**Figure 2-2 Description of sampling points at Charles R. Lowman Unit Number 2A Absorber Inlet Duct**



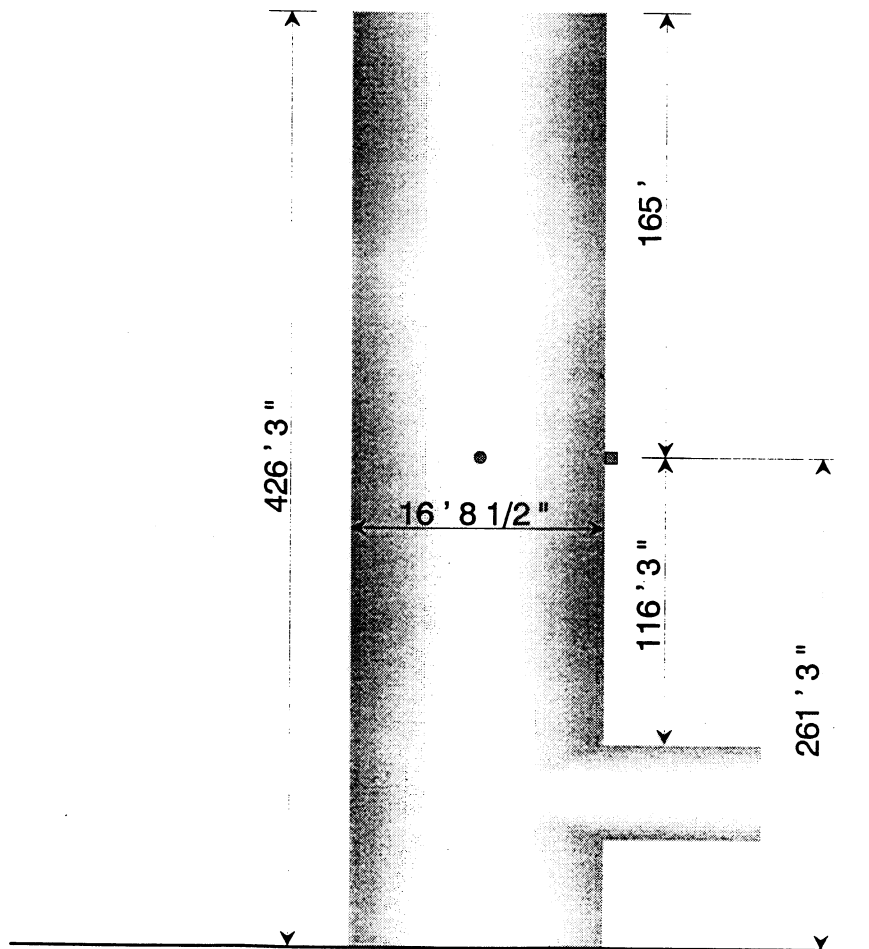
**Figure 2-3 Description of sampling locations at Charles R. Lowman Unit Number 2B Absorber Inlet Duct**



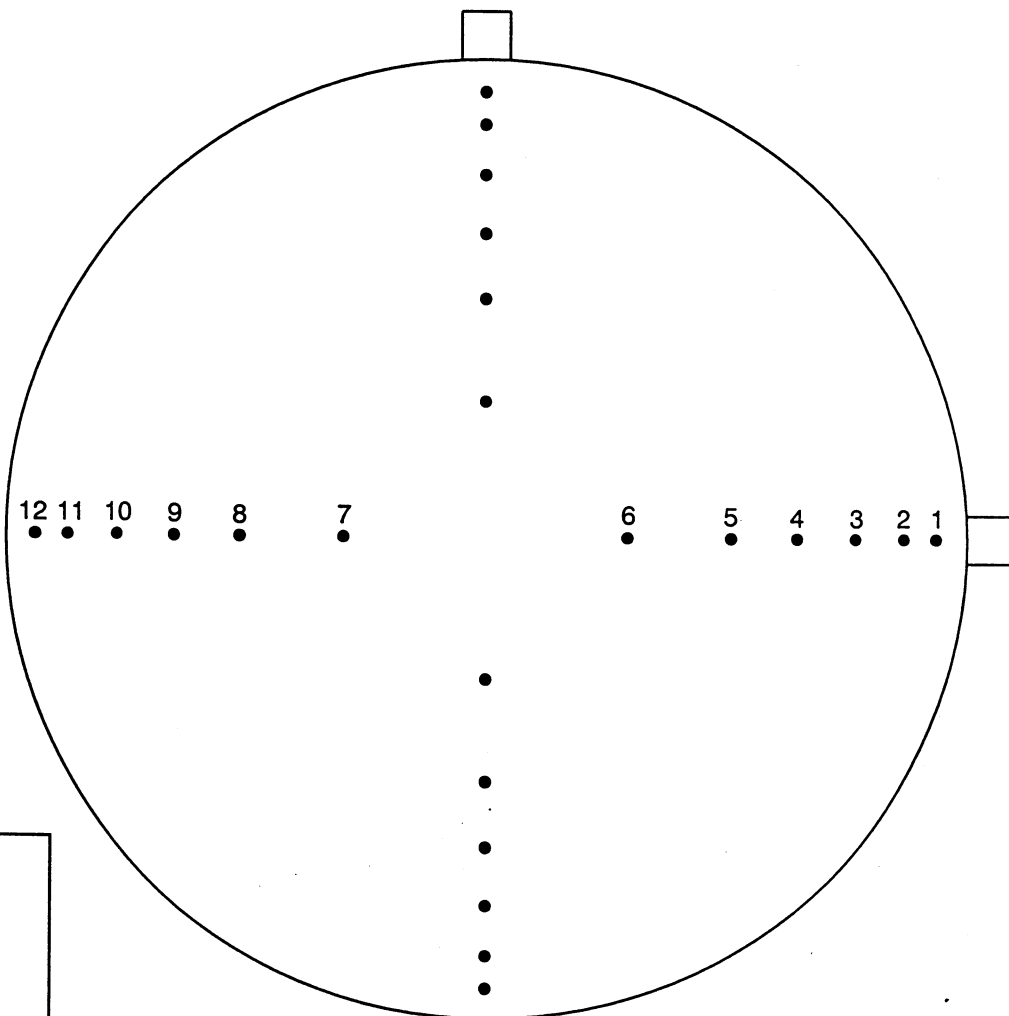
**Figure 2-4 Description of sampling points at Charles R. Lowman Unit Number 2B Absorber Inlet Duct**



**Figure 2-5 Description of sampling locations at Charles R. Lowman Unit Number 2 Stack**



**Figure 2-6 Description of sampling points at Charles R. Lowman Unit Number 2 Stack**

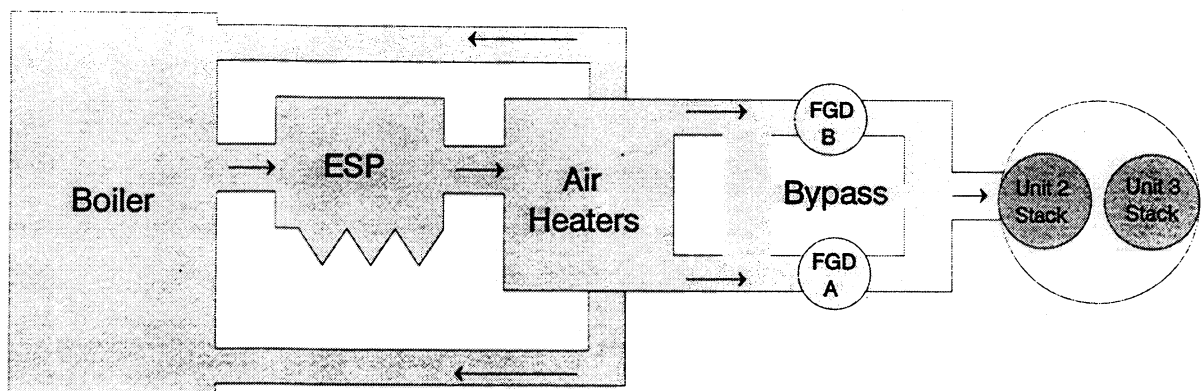


Point*	Distance from Wall
1	4 3/16 "
2	13 7/16 "
3	23 11/16 "
4	35 1/2 "
5	50 1/8 "
6	71 3/8 "
7	129 1/8 "
8	150 3/8 "
9	165 "
10	176 13/16 "
11	187 1/16 "
12	196 5/16 "

\* Only points 1 through 6 were sampled for mercury due to physical limitations of the reference method sampling equipment. All points were sampled for flow rate.

**Figure 2-7 Description of coal feeder sampling locations at Charles R. Lowman Unit Number 2**

Mill Sampling Location



### **3 SUMMARY AND DISCUSSION OF RESULTS**

#### **3.1 Objectives and Test Matrix**

##### ***3.1.1 Objective***

The objective of the tests was to collect the information and measurements required by the EPA Mercury ICR. Specific objectives listed in order of priority are:

1. Quantify speciated mercury emissions at the stack.
2. Quantify speciated mercury concentrations in the flue gas at the inlet.
3. Quantify fuel mercury and chlorine content during the stack and inlet tests.
4. Provide the above information for use in developing boiler, fuel, and specific control device mercury emission factors.

##### ***3.1.2 Test Matrix***

The test matrix is presented in Table 1. The table includes a list of test methods to be used. In addition to speciated mercury, the flue gas measurements include moisture, flue gas flow rates, carbon dioxide, and oxygen.

**Table 3-1**  
**Test Matrix for Mercury ICR Tests at Charles R. Lowman Unit Number 2**

Sampling Location	No. of Runs	Species Measured	Sampling Method	Sample Run Time	Analytical Method	Analytical Laboratory
Stack	3	Speciated Hg	Ontario Hydro	120 min	Ontario Hydro	TestAmerica
Stack	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
Stack	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Stack	3	O <sub>2</sub> & CO <sub>2</sub>	EPA 3B	Concurrent	Orsat	METCO
A Inlet	3	Speciated Hg	Ontario Hydro	120 min	Ontario Hydro	Test America
A Inlet	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
A Inlet	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
A Inlet	3	O <sub>2</sub> & CO <sub>2</sub>	EPA 3B	Concurrent	Orsat	METCO
B Inlet	3	Moisture	EPA 4	45 min	Gravimetric	METCO
B Inlet	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
B Inlet	3	O <sub>2</sub> & CO <sub>2</sub>	EPA 3B	Concurrent	Orsat	METCO
Silo	3	Hg, Cl, Sulfur, Ash, and Btu/lb in coal	ASTM D2234	1 grab sample every 24-minutes per silo per run	ASTM D6414-99 (Hg), ASTM E776/300.0 (Cl), ASTM D-4239 (S), ASTM D-3174 (Ash), and ASTM D-3286 (Btu/lb)	TestAmerica and Philip Services

### 3.2 Field Test Changes and Problems

No deviations were made from the approved Sampling and Analytical Test Plan.

### 3.3 Handling of Non-Detects

This section addresses how data will be handled in cases where no mercury is detected in an analytical fraction. It should be noted that the analytical method specified in the Ontario Hydro Method has a very low detection limit, which is expected to be well below flue gas levels for most cases if the laboratory uses normal care and state of the art analytical equipment. However, there may be cases where certain fractions of a test do not show detectable mercury levels. This section addresses how non-detects will be handled in calculating and reporting mercury levels.

#### *3.3.1 A single analytical fraction representing a subset of a mercury species is not detected.*

When more than one sample component is analyzed to determine a mercury species (such as analyzing the probe rinse and filter catch separately to determine total particulate mercury) and one fraction is not detected, it will be counted as zero. Total mercury for that species will be the sum of the detected values of the remaining fraction(s). For example, if the probe rinse had ND < 0.05 µg and the filter had 1.5 µg, total particulate mercury would be reported as 1.5 micrograms.

#### *3.3.2 All fractions representing a mercury species are not detected.*

If all fractions used to determine a mercury species are not detected, the total mercury for that species will be reported as not detected, at the sum of the detection limits of the individual species.

For example, if the probe rinse were not detected at 0.003  $\mu\text{g}$  and the filter catch were not detected at 0.004  $\mu\text{g}$ , the reported particulate mercury would be reported as ND < 0.007  $\mu\text{g}$ . This is expected to represent a small fraction (<1%) of the total mercury, even under worse case scenario of 1  $\mu\text{g}/\text{Nm}^3$ .

### *3.3.3 No mercury is detected for a species on all three test runs.*

When all three test runs show no detectable levels of mercury for a mercury species, that mercury species will be reported as not detected at less than the highest detection limit. For example, if three results for elemental mercury are ND < 0.10, ND < 0.13, and ND < 0.10, the results would be reported as ND < 0.13 (the highest of the three detection levels).

In calculating total mercury, a value of zero will be used for that species. For example, if particulate mercury were ND < 0.11  $\mu\text{g}$ , oxidized mercury were 2.0  $\mu\text{g}$ , and elemental mercury were 3.0  $\mu\text{g}$ , total mercury would be reported as 5.0  $\mu\text{g}$ .

In calculating the percentage of mercury in the other two species, a value of zero will be used. For the example listed in the preceding paragraph, the results would be reported as 0% particulate mercury, 40% oxidized mercury, and 60% elemental mercury.

### *3.3.4 Mercury is detected on one or two of three runs.*

If mercury is detected on one or two of three runs, average mercury will be calculated as the average of the detected value(s) and half of the detection limits for the non-detect(s).

Example 1: The results for three runs are 0.20, 0.20, and ND < 0.10. The reported value would be calculated as the average of 0.20, 0.20, and 0.05, which is 0.15  $\mu\text{g}$ .

Example 2: The results for three runs are 0.14, ND < 0.1, and ND < 0.1. The average of 0.14, 0.05, and 0.05 is calculated to be 0.08. Since this is below the detection limit of 0.1, the reported value is ND < 0.1.

### 3.4 Summary of Results

The results of the tests performed at Charles R. Lowman Unit Number 2 are listed in the following tables.

Run Number 1 was invalid due to an unacceptable isokentic sampling rate on the Unit Number 2A Absorber Inlet Duct.

The thimble sample (Container Number 1A) for Unit Number 2A Absorber Inlet Duct Run Number 2 was lost due to a lab accident during preparation. The sample could not be re-prepared because the entire filter was used during the initial preparation.

**Table 3-2**  
**Charles R. Lowman Unit Number 2 Source Emissions Results**

<b>A Inlet Gas Properties</b>	<b>Run Number 2</b>	<b>Run Number 3</b>	<b>Run Number 4</b>
Test Date	01/26/00	01/26/00	01/26/00
Test Time	0820-1035	1135-1335	1425-1625
Flow Rate - ACFM	131,932	153,323	142,084
Flow Rate – DSCFM*	87,832	102,535	93,680
% Water Vapor - % Vol.	7.02	6.45	7.48
CO <sub>2</sub> - %	13.2	12.8	12.9
O <sub>2</sub> - %	6.2	6.7	6.8
% Excess Air @ Sampling Point	41	46	47
Temperature - °F	294	294	296
Pressure – "Hg	30.47	30.44	30.43
Percent Isokinetic	104.0	99.3	106.5
Volume Dry Gas Sampled – DSCF*	58.264	64.943	63.618
<b>B Inlet Gas Properties</b>	<b>Run Number 2</b>	<b>Run Number 3</b>	<b>Run Number 4</b>
Test Date	01/26/00	01/26/00	01/26/00
Test Time	0820-0905	1145-1230	1425-1510
Flow Rate - ACFM	172,239	154,804	152,876
Flow Rate – DSCFM*	111,410	99,991	100,369
% Water Vapor - % Vol.	6.52	6.72	5.02
CO <sub>2</sub> - %	11.6	12.8	12.7
O <sub>2</sub> - %	8.0	6.5	6.8
% Excess Air @ Sampling Point	60	44	47
Temperature - °F	320	319	320
Pressure – "Hg	30.47	30.45	30.44
Volume Dry Gas Sampled – DSCF*	27.219	27.445	27.790
Total Inlet Flow Rate – DSCFM*	199,242	202,526	194,049
<b>Stack Gas Properties</b>	<b>Run Number 2</b>	<b>Run Number 3</b>	<b>Run Number 4</b>
Test Date	01/26/00	01/26/00	01/26/00
Test Time	0820-1028	1135-1341	1425-1631
Partial Traverse			
Flow Rate – ACFM	822,104	818,890	815,646
Flow Rate – DSCFM*	562,490	567,086	555,272
% Water Vapor - % Vol.	8.46	7.41	8.43
CO <sub>2</sub> - %	13.0	13.2	13.2
O <sub>2</sub> - %	6.6	6.4	6.4
% Excess Air @ Sampling Point	45	43	43
Temperature - °F	251	250	254
Pressure – "Hg	30.00	29.98	29.97
Percent Isokinetic	105.6	105.7	105.5
Volume Dry Gas Sampled – DSCF*	67.177	67.766	66.228
Complete Traverse			
Total Inlet Flow Rate – DSCFM*	542,840	545,071	536,170

\* 29.92 "Hg, 68 °F (760 mm Hg, 20 °C).

**Table 3-3**  
**Charles R. Lowman Unit Number 2 Mercury Removal Efficiency**

Run Number	2	3	4	Average
Test Date	01/26/00	01/26/00	01/26/00	
Test Time	0820-1035	1135-1341	1425-1631	
<b>Total mercury</b>				
Inlet - lb/10 <sup>12</sup> Btu	*	5.50	6.43	6.62
Stack - lb/10 <sup>12</sup> Btu	3.65	3.88	3.79	3.77
Removal efficiency - %	-----	29.5	41.1	35.3
<b>Particulate mercury</b>				
Inlet - lb/10 <sup>12</sup> Btu	*	1.10	2.46	1.78
Stack - lb/10 <sup>12</sup> Btu	0.04	0.05	0.04	0.04
Removal efficiency - %	-----	95.5	98.4	97.0
<b>Oxidized mercury</b>				
Inlet - lb/10 <sup>12</sup> Btu	2.38	2.84	2.53	2.58
Stack - lb/10 <sup>12</sup> Btu	1.19	1.33	1.47	1.33
Removal efficiency - %	50.0	53.2	41.9	48.4
<b>Elemental mercury</b>				
Inlet - lb/10 <sup>12</sup> Btu	1.49	1.55	1.44	1.49
Stack - lb/10 <sup>12</sup> Btu	2.42	2.50	2.28	2.40
Removal efficiency - %	-----	-----	-----	-----

\* The thimble sample for Unit Number 2A Absorber Inlet Duct Run Number 2 was lost due to a lab accident during preparation.

**Table 3-4 Charles R. Lowman Unit Number 2 Mercury Speciation Results**

Run Number	2	3	4	Average
Test Date	01/26/00	01/26/00	01/26/00	
Test Time	0820-1035	1135-1341	1425-1631	
<b>A Inlet Mercury Speciation</b>				
Particulate mercury – µg	*	2.26	4.90	—
µg/dscm	—	1.23	2.72	1.98
lbs/10 <sup>12</sup> Btu	—	1.10	2.46	1.78
% of total Hg	—	20.0	38.3	29.2
Oxidized mercury – µg	4.52	5.82	5.04	—
µg/dscm	2.74	3.16	2.80	2.90
lbs/10 <sup>12</sup> Btu	2.38	2.84	2.53	2.58
% of total Hg	—	51.6	39.3	45.5
Elemental mercury – µg	2.84	3.17	2.86	—
µg/dscm	1.72	1.72	1.59	1.68
lbs/10 <sup>12</sup> Btu	1.49	1.55	1.44	1.49
% of total Hg	—	28.2	22.4	25.3
Total mercury – µg	*	11.25	12.80	—
µg/dscm	—	6.12	7.11	6.62
lbs/10 <sup>12</sup> Btu	—	5.50	6.43	5.97
<b>Stack Mercury Speciation</b>				
Particulate mercury – µg	0.086	0.109	0.080	—
µg/dscm	0.05	0.06	0.04	0.05
lbs/10 <sup>12</sup> Btu	0.04	0.05	0.04	0.04
% of total Hg	1.1	1.3	1.1	1.2
Oxidized mercury – µg	2.54	2.89	3.14	—
µg/dscm	1.34	1.51	1.67	1.51
lbs/10 <sup>12</sup> Btu	1.19	1.33	1.47	1.33
% of total Hg	32.6	34.3	38.8	35.2
Elemental mercury – µg	5.16	5.45	4.86	—
µg/dscm	2.71	2.84	2.59	2.71
lbs/10 <sup>12</sup> Btu	2.42	2.50	2.28	2.40
% of total Hg	66.3	64.4	60.2	63.6
Total mercury – µg	7.79	8.45	8.08	—
µg/dscm	4.10	4.40	4.31	4.27
lbs/10 <sup>12</sup> Btu	3.65	3.88	3.79	3.77
<b>Coal Analysis</b>				
Mercury – ppm dry	0.084	0.077	0.080	0.080
Mercury – lbs/10 <sup>12</sup> Btu	6.98	6.67	6.98	6.88
Chlorine – ppm dry	400	400	300	367
Moisture – %	12.0	12.1	12.0	12.0
Sulfur – % dry	0.53	0.52	0.53	0.53
Ash – % dry	4.65	5.29	4.93	4.96
HHV – Btu/lb as fired	11,750	11,740	11,750	11,747
Coal flow – lbs/hr as fired	195,020	191,540	195,020	193,860
Total Heat Input – 10 <sup>6</sup> Btu/hr	2,291.5	2,248.7	2,291.5	2,277.2
<b>Total Mercury Mass Rates</b>				
lbs/hr input in coal	0.016	0.015	0.016	0.016
lbs/hr at FGD inlet**	*	0.012	0.015	0.014
lbs/hr emitted**	0.011	0.010	0.009	0.010

\* The thimble sample for Unit Number 2A Absorber Inlet Duct Run Number 2 was lost due to a lab accident during preparation.

\*\* Calculated based on the Total Heat Input (10<sup>6</sup> Btu/hr) and the measured concentration (lbs/10<sup>12</sup> Btu).

**Table 3-5**  
**Charles R. Lowman Unit Number 2 Process Data**

<b>Run Number</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>Test Date</b>	01/26/00	01/26/00	01/26/00
<b>Test Time</b>	0820-1035	1135-1341	1425-1631
<b>Unit Operation</b>			
Unit Load - MW gross	245	245	245
Mills in Service	All	All	All
Coal Flow – tons/hr	97.51	95.77	97.51
<b>CEMS data</b>			
CO <sub>2</sub> - %	12.5	12.6	12.6
SO <sub>2</sub> – lbs/10 <sup>6</sup> Btu	0.519	0.561	0.556
NO <sub>x</sub> – lbs/10 <sup>6</sup> Btu	0.416	0.421	0.424
Stack Temperature - °F	250.6	251.1	253.4
Stack flow - kscfh	37,973,199	37,624,959	37,366,879
<b>FGD data</b>			
"A" Inlet Gas Temp. - °F	310	300	300
"A" Outlet Gas Temp. - °F	116	105	105
"B" Inlet Gas Temp. - °F	320	320	320
"B" Outlet Gas Temp. - °F	115	115	115

## **4 SAMPLING AND ANALYTICAL PROCEDURES**

### **4.1 Emission Test Methods**

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the Ontario Hydro Method, Revised July 7, 1999, and ASTM Methods D2234, D6414-99, E776/300.0, D-4239, D-3174, and D-3286.

A preliminary velocity traverse was made at each of the four ports on the Unit Number 2A Absorber Inlet Duct, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 2.3 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. Three traverse points were sampled from each of the eight ports for a total of twenty-four traverse points.

A preliminary velocity traverse was made at each of the four ports on the Unit Number 2B Absorber Inlet Duct, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 10.1 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. Three traverse points were sampled from each of the eight ports for a total of twenty-four traverse points.

A preliminary velocity traverse was made at each of the two ports on the Unit Number 2 South Stack, in order to determine the uniformity and magnitude of the flow prior to testing. Twelve traverse points were checked for cyclonic flow and the average angle was equal to 0.8 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. For the mercury testing (partial traverse), six traverse points were sampled from each of the two ports for a total of twelve traverse points. For the flow testing (complete traverse), twelve traverse points were sampled from each of the two ports for a total of twenty-four traverse points.

The sampling trains were leak-checked at the end of the nozzle at 15 inches of mercury vacuum before each test, and again after each test at the highest vacuum reading recorded during each test. This was done to predetermine the possibility of a diluted sample.

The pitot tube lines were checked for leaks before and after each test under both a vacuum and a pressure. The lines were also checked for clearance and the manometer was zeroed before each test.

Integrated orsat samples were collected and analyzed according to EPA Method 3B during each test.

#### **4.1.1 Mercury**

Triplicate samples for mercury were collected. The samples were taken according to EPA Methods 1, 2, 3B, 4, 5 and 17; and the Ontario Hydro Method, Revised July 7, 1999. For each run at the inlet sampling location, samples of five-minute duration were taken isokinetically at each of the twenty-four traverse points for a total sampling time of 120 minutes. For each run at the stack sampling location, samples of ten-minute duration were taken isokinetically at each of the twelve sampling points for a total sampling time of 120 minutes. Data was recorded at five-minute intervals. Reagent blanks and field blanks were submitted.

The "front-half" of the sampling train at the inlet sampling location contained the following components:

Teflon Coated Nozzle  
In-stack Quartz Fiber Thimble and Backup Filter and Teflon Coated Support  
Heated Glass Probe @ > 248°F

The "front-half" of the sampling train at the stack sampling location contained the following components:

Teflon Coated Nozzle  
Heated Glass Probe @ > 248°F  
Heated Quartz Fiber Filter and Teflon Support @ > 248°F

The "back-half" of the sampling train at both sampling locations contained the following components:

<u>Impinger Number</u>	<u>Impinger Type</u>	<u>Impinger Contents</u>	<u>Amount</u>	<u>Parameter Collected</u>
1	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
2	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
3	Greenburg-Smith Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
4	Modified Design	5% HNO <sub>3</sub> and 10% H <sub>2</sub> O <sub>2</sub>	100 ml	Elemental Mercury and Moisture
5	Modified Design	4% KMnO <sub>4</sub> and 10% H <sub>2</sub> SO <sub>4</sub>	100 ml	Elemental Mercury and Moisture
6	Modified Design	4% KMnO <sub>4</sub> and 10% H <sub>2</sub> SO <sub>4</sub>	100 ml	Elemental Mercury and Moisture
7	Greenburg-Smith Design	4% KMnO <sub>4</sub> and 10% H <sub>2</sub> SO <sub>4</sub>	100 ml	Elemental Mercury and Moisture
8	Modified Design	Silica Gel	200 g	Moisture

All glassware was cleaned prior to use according to the guidelines outlined in EPA Method 29, Section 5.1.1 and the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.15. All glassware connections were sealed with Teflon tape.

At the conclusion of each test, the filter and impinger contents were recovered according to procedures outlined in the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.

Mercury samples were analyzed by Cold Vapor Atomic Absorption and Fluorescence Spectroscopy.

#### 4.1.2 Moisture

The samples were taken according to EPA Methods 3B and 4. Samples of forty five-minute duration were taken from a single point. Data was recorded in five-minute intervals.

The "front-half" of the sampling train at the outlet sampling location contained the following components:

In-stack Quartz Fiber Filter and Teflon Coated Support  
Heated Glass Probe @ > 248°F

The "back-half" of the sampling train contained the following components:

<u>Impinger Number</u>	<u>Impinger Type</u>	<u>Impinger Contents</u>	<u>Amount</u>	<u>Parameter Collected</u>
1	Modified Design	6% Hydrogen Peroxide	100 ml	Moisture
2	Greenburg-Smith Design	6% Hydrogen Peroxide	100 ml	Moisture
3	Modified Design	6% Hydrogen Peroxide	100 ml	Moisture
4	Modified Design	Silica Gel	200 g	Moisture

#### 4.2 Process Test Methods

ASTM D2234 method of coal sampling was followed. For each test run, a grab sample of coal was collected from the inlet of each individual feeder. One composite sample was prepared for analysis from the individual feeder samples. Each sample was analyzed for mercury, chlorine, sulfur, ash, and Btu content by ASTM Methods D6414-99, E766/300.0, D-4239, D-3174, and D-3286, respectively.

#### 4.3 Sample Tracking and Custody

Samples and reagents were maintained in limited access, locked storage at all times prior to the test dates. While on site, they were at an attended location or in an area with limited access. Off site, METCO and TestAmerica provided limited access, locked storage areas for maintaining custody.

Chain of custody forms are located in Appendix F. The chain of custody forms will provide a detailed record of custody during sampling, with the initials noted of the individuals who load and recover impingers and filters and perform probe rinses.

All samples were packed and shipped in accordance with regulations for hazardous substances.

## 5 QA/QC ACTIVITIES

The major project quality control checks are listed in Table 5-1. Matrix Spike Summaries are listed in Table 5-2. Duplicate and Triplicate Analyses Summaries are listed in Table 5-3. Additional method-specific QC checks are presented in Table 5-4 (Methods 1 and 2), Table 5-5 (Method 5/17 sampling), and Table 5-6 (Ontario Hydro sample recovery and analysis). These tables also include calibration frequency and specifications.

**Table 5-1**  
**Major Project Quality Control Checks**

<i>QC Check</i>	<i>Information Provided</i>	<i>Results</i>
<i>Blanks</i>		
Reagent blank	Bias from contaminated reagent	0.009 µg of Mercury was detected in the Thimble Reagent Blank
Field blank	Bias from handling and glassware	Low levels of Mercury were detected
<i>Spikes</i>		
Matrix spike	Analytical bias	Sample results were between 75% - 125% recovery
<i>Replicates</i>		
Duplicate analyses	Analytical precision	Results were < 10% RPD
Triplicate analyses	Analytical precision	Results were < 10% RPD

**Table 5-2**  
**Matrix Spike Summary**

<i>Sampling Location</i>	<i>Run Number</i>	<i>Container</i>	<i>Results (<math>\mu</math>g)</i>	<i>True Value (<math>\mu</math>g)</i>	<i>Recovery (%)</i>
2A Inlet	1	1A	7.91	7.50	105
2A Inlet	3	1A	2.91	3.00	97
2A Inlet	4	4	0.337	0.360	94
2A Inlet	4	5	4.48	4.15	109
Stack	4	2	0.201	0.189	106
Stack	4	3	4.02	3.68	109
Stack	4	4	0.334	0.360	93
Stack	4	5	3.28	3.60	91
Reagent Blank	----	88QH98	0.054	0.050	108

**Table 5-3**  
**Duplicate and Triplicate Analyses Summary**

<i>Sampling Location</i>	<i>Run Number</i>	<i>Container</i>	<i>Results (µg)</i>	<i>Duplicate Results (µg)</i>	<i>RPD</i>	<i>Triplicate Results (µg)</i>	<i>RPD</i>
2A Inlet Duct	2	1A	*	----	----	----	----
		1B	0.012	0.012	3.3	0.012	2.4
		2	0.092	0.094	1.7	----	----
		3	4.52	4.37	3.2	----	----
		4	<0.020	<0.020	<1.0	----	----
		5	2.84	2.77	2.6	----	----
	3	1A	2.21	2.26	2.1	----	----
		1B	0.007	0.007	<1.0	----	----
		2	0.045	0.045	<1.0	----	----
		3	5.82	5.86	<1.0	----	----
		4	0.021	0.022	5.8	0.023	9.5
		5	3.15	3.10	1.6	3.13	<1.0
	4	1A	4.79	4.70	1.9	----	----
		1B	0.009	0.009	1.2	----	----
		2	0.099	0.099	<1.0	----	----
		3	5.04	4.90	2.8	----	----
		4	<0.018	<0.018	<1.0	----	----
		5	2.86	2.87	<1.0	----	----
Stack	2	1A	0.035	0.036	4.9	----	----
		2	0.051	0.051	<1.0	----	----
		3	2.54	2.52	<1.0	----	----
		4	0.040	0.039	2.8	----	----
		5	5.12	5.03	1.7	----	----
	3	1A	0.062	0.064	2.4	----	----
		2	0.047	0.045	3.1	0.045	4.9
		3	2.89	2.85	1.4	2.96	2.2
		4	0.039	0.040	2.7	0.041	3.6
		5	5.41	5.25	3.1	5.33	1.5
	4	1A	0.043	0.043	<1.0	0.044	<1.0
		2	0.037	0.036	4.1	----	----
		3	3.14	3.09	1.9	----	----
		4	<0.018	<0.018	<1.0	----	----
		5	4.86	4.82	<1.0	----	----

\* The thimble sample for Unit Number 2A Absorber Inlet Duct Run Number 2 was lost due to a lab accident during preparation.

**Table 5-4**  
**QC Checklist and Limits for Methods 1 and 2**

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Measurement site evaluation	>2 diameters downstream and 0.5 diameters upstream of disturbances	Method 1, Section 2.1
Pitot tube inspection	Inspect each use for damage, once per program for design tolerances	Method 2, Figures 2-2 and 2-3
Thermocouple	+/- 1.5% (°R) of ASTM thermometer, before and after each test mobilization	Method 2, Section 4.3
Barometer	Calibrate each program vs. mercury barometer or vs. weather station with altitude correction	Method 2, Section 4.4

Although the Unit Number 2A and 2B Absorber Inlet Ducts sampling locations did not meet the requirements of Method 1, three-dimensional flow testing as described in Method 1 was not performed. A preliminary velocity traverse was made at each of the eight ports on the Unit Number 2A Absorber Inlet Duct, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 2.3 degrees. A preliminary velocity traverse was made at each of the eight ports on the Unit Number 2B Absorber Inlet Duct, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 10.1 degrees.

**Table 5-5**  
**QC Checklist and Limits for Method 5/17 Sampling**

Quality Control Activity	Acceptance Criteria and Frequency	Reference
<i>Pre-mobilization checks</i>		
Gas meter/orifice check	Before test series, $Y_D \pm 5\%$ (of original $Y_D$ )	Method 5, Section 5.3
Probe heating system	Continuity and resistance check on element	
Nozzles	Note number, size, material	
Glassware	Inspect for cleanliness, compatibility	
Thermocouples	Same as Method 2	
<i>On-site pre-test checks</i>		
Nozzle	Measure inner diameter before first run	Method 5, Section 5.1
Probe heater	Confirm ability to reach temperature	
Pitot tube leak check	No leakage	Method 2, Section 3.1
Visible inspection of train	Confirm cleanliness, proper assembly	
Sample train leak check	$\leq 0.02$ cf at 15" Hg vacuum	Method 5, Section 4.1.4
<i>During testing</i>		
Probe and filter temperature	Monitor and confirm proper operation	
Manometer	Check level and zero periodically	
Nozzle	Inspect for damage or contamination after each traverse	Method 5, Section 5.1
Probe/nozzle orientation	Confirm at each point	
<i>Post test checks</i>		
Sample train leak check	$\leq 0.02$ cf at highest vacuum achieved during test	Method 5, Section 4.1.4
Pitot tube leak check	No leakage	Method 2, Section 3.1
Isokinetic ratio	Calculate, must be 90-110%	Method 5, Section 6
Dry gas meter calibration check	After test series, $Y_D \pm 5\%$	Method 5, Section 5.3
Thermocouples	Same as Method 2	
Barometer	Compare w/ standard, $\pm 0.1$ " Hg	

**Table 5-6 QC Checklist and Limits for Ontario Hydro Mercury Speciation**

Quality Control Activity	Acceptance Criteria and Frequency	Reference
<i>Pre-mobilization activities</i>		
Reagent grade	ACS reagent grade	Ontario Hydro Section 8.1
Water purity	ASTM Type II, Specification D 1193	Ontario Hydro Section 8.2
Sample filters	Quartz; analyze blank for Hg before test	Ontario Hydro Section 8.4.3
Glassware cleaning	As described in Method	Ontario Hydro Section 8.10
<i>On-site pre-test activities</i>		
Determine SO <sub>2</sub> concentration	If >2500 ppm, add more HNO <sub>3</sub> -H <sub>2</sub> O <sub>2</sub> solution	Ontario Hydro Section 13.1.13
Prepare KCl solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare HNO <sub>3</sub> -H <sub>2</sub> O <sub>2</sub> solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare H <sub>2</sub> SO <sub>4</sub> -KMnO <sub>4</sub> solution	Prepare daily	Ontario Hydro Section 8.5
Prepare HNO <sub>3</sub> rinse solution	Prepare batch as needed; can be purchased premixed	Ontario Hydro Section 8.6
Prepare hydroxylamine solution	Prepare batch as needed	Ontario Hydro Section 8.6
<i>Sample recovery activities</i>		
Brushes and recovery materials	No metallic material allowed	Ontario Hydro Section 13.2.6
Check for KMnO <sub>4</sub> Depletion	If purple color lost in first two impingers, repeat test with more HNO <sub>3</sub> -H <sub>2</sub> O <sub>2</sub> solution	Ontario Hydro Section 13.1.13
Probe cleaning	Move probe to clean area before cleaning	Ontario Hydro Section 13.2.1
Impinger 1,2,3 recovery.	After rinsing, add permanganate until purple color remains to assure Hg retention	Ontario Hydro Section 13.2.8
Impinger 5,6,7 recovery.	If deposits remain after HNO <sub>3</sub> rinse, rinse with hydroxylamine sulfate. If purple color disappears after hydroxylamine sulfate rinse, add more permanganate until color returns	Ontario Hydro Section 13.2.10
Impinger 8	Note color of silica gel; if spent, regenerate or dispose.	Ontario Hydro Section 13.2.11
<i>Blank samples</i>		
0.1 N HNO <sub>3</sub> rinse solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
KCl solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
HNO <sub>3</sub> -H <sub>2</sub> O <sub>2</sub> solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
H <sub>2</sub> SO <sub>4</sub> -KMnO <sub>4</sub> solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Hydroxylamine sulfate solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Unused filters	Three from same lot.	Ontario Hydro Section 13.2.12
Field blanks	One per set of tests at each test location.	Ontario Hydro Section 13.4.1
<i>Laboratory activities</i>		
Assess reagent blank levels	Target <10% of sample value or <10x instrument detection limit. Subtract as allowed.	Ontario Hydro Section 13.4.1
Assess field blank levels	Compare to sample results. If greater than reagent blanks or greater than 30% of sample values, investigate. Subtraction of field blanks not allowed.	Ontario Hydro Section 13.4.1
Duplicate/triplicate samples	All CVAAS runs in duplicate; every tenth run in triplicate. All samples must be within 10% of each other; if not, recalibrate and reanalyze.	Ontario Hydro Section 13.4.1

## 6 DESCRIPTION OF TESTS

Personnel from METCO Environmental arrived at the plant at 8:00 a.m. on Tuesday, January 25, 2000. After meeting with plant personnel, the equipment was moved onto the Unit Number 2A and 2B Absorber Inlet Ducts and the Unit Number 2 Stack. The preliminary data was collected. Testing was delayed due to reference method equipment problems. The first test for flow rate on the Unit Number 2 Stack began at 4:45 p.m. and was completed at 5:05 p.m. The first test for flow rate on the Unit Number 2B Absorber Inlet Duct began at 4:50 p.m. and was completed at 5:35 p.m. The first set of tests for mercury on the Unit Number 2A Absorber Inlet Duct and the Unit Number 2 Stack began at 4:50 p.m. and was completed at 7:01 p.m. The equipment was secured for the night. All work was completed at 8:45 p.m. Run Number 1 was invalid due to an unacceptable isokinetic sampling rate on the Unit Number 2A Absorber Inlet Duct.

On Wednesday, January 26, work began at 7:00 a.m. The equipment was prepared for testing. The second test for flow rate on the Unit Number 2 Stack began at 8:15 a.m. Testing continued until the completion of the fourth test at 2:35 p.m. The second test for flow rate on the Unit Number 2B Absorber Inlet Duct began at 8:20 a.m. Testing continued until the completion of the fourth test at 3:10 p.m. The second set of tests for mercury on the Unit Number 2A Absorber Inlet Duct and Unit Number 2 Stack began at 8:20 a.m. Testing continued until the completion of the fourth set of tests at 4:31 p.m.

The samples were recovered. The equipment was moved off of the sampling locations and loaded into the sampling van. The samples and the data were transported to METCO Environmental's laboratory in Dallas, Texas, for analysis and evaluation.

Operations at Alabama Electric Cooperative, Charles R. Lowman Plant, Unit Number 2A and 2B Absorber Inlet Ducts and the Unit Number 2 Stack, located in Leroy, Alabama, for the Electric Power Research Institute, were completed at 6:45 p.m. on Wednesday, January 26, 2000.



Billy J. Mullins, Jr. P.E.  
President

## **7 APPENDICES**

- A. Source Emissions Calculations
- B. Field Data
- C. Calibration Data
- D. Analytical Data
- E. Unit Operational Data
- F. Chain of Custody Records
- G. Resumes